Photothermal Depth Profiling by Genetic Algorithms and Thermal Wave Backscattering

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Photothermal depth profiling has been the subject of many papers in the last years. Inverse problems on different kind of materials have been identified, classified and solved. A first classification has been done according to the type of depth profile: the physical quantity to be reconstructed is the optical absorption in the problems of type I, the thermal effusivity for type II, and both of them for type III. Another classification may be done depending on the time scale of the pump beam heating (frequency scan, time scan), or on its geometrical symmetry (1D, 3D). In this paper we want to discuss two different approaches, the Genetic Algorithms (GA) and the Thermal Wave Backscattering (TWBS), showing the performances and limits of validity for several kind of photothermal depth profiling problems. These two approaches are based on different mechanisms and exhibit obviously different features. GA may be implemented on the exact heat diffusion equation as follows: one chromosome is associated to each profile. The genetic evolution of the chromosome allows one to find better and better profiles, eventually converging towards the solution of the inverse problem. The main advantage is that GA may be applied to any arbitrary profile, but several disadvantages exist, for example the complexity of the algorithm, the slowness of convergence, and consequently the computer time consumption. On the contrary TWBS uses a simplified theoretical model of heat diffusion in inhomogeneous materials. According to such a model the photothermal signal depends linearly on the thermal effusivity inhomogeneities, which may be detected because they act as backscattering centres for the heat flux. The physical problem is reduced to the inversion of a algebraic linear system. The advantage is that TWBS allows excellent reconstructions, but only within the limits of validity of the approximate model, which anyway includes any slowly varying profile.